phoid bacillus or any specific forms other than *B. coli communis*. For obvious reasons it is inadvisable at this time to give this phase of water analysis any detailed consideration.

SUNSPOTS AND RAINFALL.*

AT the meeting of the Royal Society on November 22d, Sir Norman Lockyer and Dr. W. J. S. Lockyer presented a paper on 'Solar Changes of Temperature and Variations in Rainfall in the Region Surrounding the Indian Ocean.'

Sir Norman Lockyer, who made the communication, said the fact that the abnormal behavior of the widened lines in the spectra of sunspots since 1894 had been accompanied by irregularities in the rainfall of India, suggested the study and correlation of various series of facts that might be expected to throw light on the matter. Among the conclusions thus arrived at were: (1) A discussion of the chemical origin of lines most widened in sunspots at periods of *maxima* and *minima* indicated a considerable rise above the mean temperature of the sun around the years of sunspot *maximum* and a considerable fall around those of sunspot *minimum*. (2) From the facts of rainfall in India (during the southwest monsoon) and Mauritius between the years 1877 and 1886, as given by Blanford and Meldrum, the effects of these solar changes were seen to be felt in India at sunspot *maximum* and in Mauritius at sunspot *minimum*, the greater effect being in Mauritius. The pulse in Mauritius at sunspot *minimum* was also felt in India, giving rise generally to a secondary *maximum*. India, therefore, had two pulses of rainfall, one near the *maximum* and the other near the *minimum* of the sunspot period. (3) The dates of the beginning of these two pulses in the Indian and Mauritius rainfall were related to the sudden remarkable changes in the behavior of the widened lines. (4) All the famines recorded in the Famine Commission reports as having devastated India during the last half-century occurred in the intervals between these two pulses. (5) Investigation of the changes in (*a*) the widened lines (*b*) the rainfall of India, and (*c*) the rainfall of Mauritius during and after the last *maximum* in 1893 showed in all three important variations from those exhibited during and after the last *maximum* of 1883. The *minimum* of 1888–89 resembled the preceding *minimum* of 1878–79. (6) From 1849–1878 the lowest Niles recorded occurred between the same intervals. (7) Although the relations of these intervals to the droughts of Australia and of Cape Colony, and to the variations of rainfall in extra-tropical regions generally, had not been investigated, a general agreement had been made out between the intervals and the rainfall of Scotland, and both pulses had been traced in the rainfalls of Cordoba and the Cape of Good Hope. (8) The results of the inquiry having been placed before Mr. John Eliot, Meteorological Reporter to the Indian Government, he gave it as his opinion that they accorded closely with all the known facts of the large abnormal features of the temperature, pressure, and rainfall in India during the last twenty-five years, and that hence the inductions already arrived at would be of great service in forecasting future droughts in India.

When the image of a sunspot was thrown on the slit of a spectroscope, examination of the spectrum indicated that the blackness of the spot was due not only to general but also to selective absorption, and that the lines widened by the selective absorption varied from time to time. From many years' observations of these widened lines it appeared that at some periods they were distinctly traceable to known elements, while at others their origins had not been

* From the London *Times*.

discovered and they were classed as unknown lines. Comparison of these two periods, with the sunspot curve as constructed from the measurements of the mean spotted area for each year, indicated that when that area was greatest the widened lines belonged to the unknown class, but when it was least to the known class. Now, in the laboratory it was possible to differentiate between three stages of temperature—that of the flame, of the electric arc and of the electric spark of the highest tension. At the lowest temperature—that of the flame—a certain set of lines was obtained; as the temperature of the arc was reached a new set was seen; and at the temperature of the high tension spark other lines, called enhanced lines, were added, while many of the arc lines waned in intensity. At sunspot *minimum*, when the known lines were most numerous, the lines were almost invariably those seen most prominently in the arc. But as the *minimum* passed towards the *maximum* the unknown lines gradually obtained the predominance, and these were possibly 'enhanced' lines, indicating the action of a much higher temperature on known substances. It was therefore justifiable to assume a great increase of temperature at the sunspot *maximum* where these unknown lines appeared. The curves of the known and the unknown lines had been obtained by determining for each quarter of a year the percentage numbers of the two kinds, and plotting them as ordinates with the time elements as abscissæ. But for the purposes of the investigation, instead of using the mean curves of all the known elements involved, that for iron alone was employed, since that metal was a good representative of the known elements, and had been most fully studied. Such curves when drawn crossed each other at points where the percentage of unknown lines was increasing and that of iron or known lines decreasing, and *vice versa*. There seemed, therefore, to be three well-marked stages of solar temperature. At the crossing points, where the numbers of known and unknown lines were about equal, a mean condition might be assumed, a *plus* pulse or condition of temperature being indicated when the unknown lines reached their *maximum*, and a *minus* pulse when the known ones reached their *maximum*. The curves obtained during the last 20 years endorsed the conclusion that the unknown lines curve varied directly and the iron-lines curve inversely with the sunspot area. The widened-line curves were quite different from those furnished by the sunspots. The crossings were sharply marked, and since 1879 three of them had occurred, indicating the presence of mean solar temperature conditions in 1881, 1886-87, and 1892; another such crossing was anticipated in 1897, but has not as yet taken place. Sunspots were indications of excess, not of defect, of heat, and it was now known that the spots at *maximum* were really full of highly heated vapors produced by the prominences, which were most numerous when the solar atmosphere was most disturbed. The Indian meteorologists had abundantly proved that the increased radiation from the sun on the upper air currents at *maximum* was accompanied by a lower temperature in the lower strata, and that with this disturbance of the normal temperature pressure changes must be expected. Chambers was the first to show that large spotted area was accompanied by low pressures over the land surface of India. To pass from the consideration of individual spots to the zones of prominences with which they were probably associated, it was of the highest interest to note the solar latitudes occupied when the crossings already referred to took place, as in this way were discovered the belts of prominences which were really effective in pro-

ducing the increased radiation. The area of these being much larger a considerable difference of radiation might be expected —a fact it was all the more necessary to point out, because the insignificance of the area occupied by the spots had been used as an argument against any easily recognized connection between solar and terrestrial meteorological changes. Assuming two belts of prominences north and south 10° wide, with their centers over latitude 16°, one-sixth of the sun's visible hemisphere would be in a state of disturbance.

The authors' object in studying rainfall was to ascertain whether the *plus* and *minus* temperature pulses in the sun were echoed by *plus* and *minus* pulses of rainfall on the earth. The rainfall tables published by the Indian Government were first studied with special reference to the southwest monsoon, and it soon became evident that in many parts of India the *plus* and *minus* conditions of solar temperature were accompanied by *plus* and *minus* pulses producing pressure changes and heavy rains in the Indian Ocean and surrounding land. These occurred generally in the first year following the mean condition—viz., in 1877–78 and 1882–83, dates approximating to, but followed by, the *maximum* and *minimum* periods of sunspots. It was especially in regions such as Malabar and Konkan, where the monsoon struck the west coast of India, that the sharpness and individuality of these pulses were the most obvious. The study of Eliot's table of the rainfall of all India from 1875 to 1896 revealed predominant pulses in 1889 and 1893, following those of 1877–78 and 1882–83, so that it enabled the working of the same law—of the mean solar temperature being followed by a pulse of rainfall—to be traced through another sunspot cycle. The 'whole India' curve between 1875 and 1896 was also used to test whether the sun pulses, which were found to be bound up with the Indian rainfall, were in any way related to the variations often pointed out in the snowfall on the Himalayas; it was found that the values occurring at the *plus* and *minus* pulses were among the highest. Hence it appeared that the quantity both of rain and snow was increased in the years of the rise both of the unknown and of the iron lines. For the Mauritius the rainfall curve, plotted from 1877 to 1886, was seen to be fairly regular, showing alternately an excess and a deficiency of rainfall. The highest points of the curve were reached in 1877 and 1882, the lowest in 1880 and 1886. Thus the *maximum* rainfall of 1877 occupied about a year after the rise of the known lines in 1876, while the next pulse of rainfall in 1882 followed the succeeding crossing when the unknown lines were going up, also about a year later. The curves expressing the rainfall for the Cape and Cordoba for the same period showed two prominent *maxima* in the years 1878 and 1883, corresponding nearly with the *plus* and *minus* pulses of solar temperature. On comparing them also with the Bombay and Mauritius curves for the same period, it was found that the pulses indicated at Bombay occurred simultaneously with those of 1878 and 1883, but in Mauritius the effect of each of the pulses was felt a year or so earlier—namely in 1877 and 1882. The rainfall curve for Batavia for this period had its prominent *maximum* in 1882, as in Mauritius, thus preceding by a year the pulse felt at the Cape, Cordoba and Bombay in 1883.

Unless the pulses either overlapped or became continuous, there would obviously be intervals between the ending of one and the beginning of another. The *plus* and *minus* pulses, to which attention had chiefly been directed, were limited in duration, and when they ceased the quantity of water falling in the Indian area was not sufficient without water storage for the purposes of agriculture. They were followed, therefore,

by droughts, and subsequently, at times by famines. Thus, taking the period from 1877 to 1889, there was rain from the *minus* pulse in 1877–78–79 (part); no rain pulse in 1879 (part)–80–81 (part); rain from *plus* pulse 1881 (part) 82–83–84 (part); no rain pulse in 1884 (part)–86–87; and rain from the *minus* pulse in 1887 (part)–88–89. All the Indian famines since 1836 had occurred in these intervals, carried back in time on the assumption of an 11-year cycle. Thus, taking 1880 as the central year on the ascending curve, it was itself a year of famine in Madras and the North-West Provinces; also

1880 — 11 = 1869, N.W.P. famine (1868–69)
1869 — 11 = 1858, N.W.P. famine (1860)
1858 — 11 = 1847,
1847 — 11 = 1836, Great famine in Upper India (1837–38). Again, taking 1885–1886 as the central years on the descending curve:—

1885–86, Bengal and Madras famines (1884–85)
(1885-86)—11=1874–75, N. W. P. famine (1873–74)
Bombay famine (1875–76)
Bombay and Upper India famines (1876–77)
(1874–75) — 11 = 1863-64, Madras and Orissa famines (1865–66)
(1863-64) — 11 = 1852-53, Madras famine (1854).

It was clear from this table that if as much had been known in 1836 as was known now, the probability of famines at all the subsequent dates indicated might have been foreseen. The dates might also be carried forward from 1880; thus—

1880 + 11 = 1891, N.W.P. famine (1890)
Madras, Bombay and Bengal famines (1891–92)
(1885-1886) + 11 = 1896–97, General famine.

Famine years in India were usually years of low flood in Egypt, and it might be pointed out that the highest Niles followed, at an interval of one or two years, the years of the *plus* and *minus* pulses. As to the great Indian famine of last year, the widened line curves, so far from having crossed in 1897 or 1898, as they ought according to the few precedents available, had not crossed even now; in other words, the condition of ordinary solar mean temperature had not even yet been reached. Now India in a normal cycle was supplied from the southern ocean during the *minimum* sunspot period, and the rain was due to some pressure effect brought about in high southern latitudes by the sun at *minus* temperature. But as this temperature condition was not reached in 1899, as it would have been in a normal year, the rain failed. Thus the only abnormal famine recorded since 1836 occurred precisely at the time when an abnormal effect of an unprecedented *maximum* of solar temperature was revealed by the study of the widened lines.

THE ULKE COLLECTION OF COLEOPTERA.

THE collection of Coleoptera brought together during the last 50 years by Henry Ulke, of Washington, D. C., has been purchased by the Carnegie Museum, of Pittsburgh, Pa.

Henry Ulke, artist, musician, entomologist—a noticeable character from many points of view—having passed beyond his eightieth birthday, has given up his entomological collections, but by no means his interest in this branch of science. The writer met him the other day in Washington, active, alert, clear-eyed, with a complexion like a child's, and asked him how it was that he retained his youth at 10 years beyond the allotted space of life. The reply was wittily characteristic and contained a characteristic truth: "In the first place," said Ulke, "I was very careful in my choice of parents; and in the second place, my love of Nature has kept me constantly in the woods and fields throughout all my life."

The Ulke collection of Coleoptera is one of the largest and, historically and in other